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INTERLOCKING FLOORBOARD TILE SYSTEM AND METHOD OF MANUFACTURE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to floor tile systems. More particularly, the present invention relates to an interlocking tile system having individual tiles that provide the appearance of wood floorboards.

Related Art

Numerous types of flooring have been used to create multi-use surfaces for sports, as well as for other purposes. In recent years, the use of modular flooring assemblies made of synthetic materials has grown in popularity. Modular flooring systems generally comprise a series of interlocking tiles that can be permanently installed over a subfloor, such as concrete or wood, or temporarily laid down upon another surface from time to time when needed.

Such synthetic floors are advantageous for several reasons. One reason for the popularity of these types of systems is that they are typically formed of materials that are generally inexpensive and lightweight. Additionally, if one tile becomes damaged, it can be removed and replaced quickly and easily. If the flooring needs to be temporarily removed, the individual tiles making up the floor can easily be detached and stored for subsequent use.

Another reason for the popularity of these types of flooring assemblies is that the durable plastics from which they are formed are long-lasting. Also, unlike some other long-lasting alternatives, such as asphalt and concrete, interlocking tiles of polymer material are generally better at absorbing impact, and there is less risk of injury if a person falls on the plastic material, as opposed to concrete or asphalt. Moreover, the connections for modular flooring assemblies can be specially engineered to absorb lateral force to reduce injuries, as is described in U.S. Patent No. 4,930,286. Additionally, these flooring assemblies generally require little maintenance as compared to other flooring, such as natural wood floors.

However, the appearance of a natural wood floor is considered very pleasing. Despite the advantages of modular polymer flooring assemblies, many people prefer the

appearance of a wood floor. Interlocking polymer floor tile systems that have been produced heretofore have not been capable of providing such an appearance.

SUMMARY OF THE INVENTION

In one embodiment thereof, the present invention advantageously provides an interlocking polymer floorboard tile comprising an elongate rectangular plank having a length, a width, and sides, the length being at least four times the width, such that the plank resembles a wood floorboard. The elongate tile includes a top surface, a perimeter wall supporting the top surface and defining a perimeter boundary of the tile, a lattice-type support structure, supporting the top surface, and interlocking structure of loops and pins configured to mate and interlock with pins of adjacent similar tiles to form a floor covering resembling a natural wood plank floor.

In accordance with a more detailed aspect of the invention, the elongate plank includes a wood grain pattern imprinted on its top surface, to enhance the appearance of a natural wood floor.

In accordance with yet another more detailed aspect thereof, the invention advantageously provides an interlocking floor tile system, comprising a plurality of elongate rectangular polymer floor tiles having a length, a width, and sides, wherein, the plurality of elongate floor tiles are disposed on a substrate in parallel orientation with the interlocking structure of each tile interconnected to an adjacent tile, so as to form a floor covering resembling a wood plank floor.

In accordance with yet another more detailed aspect thereof, the invention advantageously provides a method for producing interlocking floor tiles, comprising the steps of providing an elongate, injection-molded polymer floor tile having a top surface and a length at least four times a width thereof, transferring a printed pattern to the top surface after molding of the tile, and applying a protective coating atop the printed pattern.

Additional features and advantages of the invention will be apparent from the detailed description which follows, taken in conjunction with the accompanying drawings, which together illustrate, by way of example, features of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top perspective view of a polymeric floorboard tile having a top surface with a wood grained appearance.

FIG. 2 is a bottom perspective view of one embodiment of a floorboard tile according to FIG. 1, having a hexagonal cell bottom support structure.

FIG. 3 is a bottom perspective view of an alternative embodiment of a floorboard tile according to FIG. 1, having a bottom support structure comprising hexagonal cells with arched ribs.

FIG. 4 is a top plan view of the floorboard tile of FIG. 1.

FIG. 5 is a split bottom plan view of the bottom support structure of the tiles of FIG. 2 and FIG. 3.

FIG. 6 is a schematic diagram of an assembly line manufacturing process for producing floor tiles according to the present invention.

FIG. 7 is a block diagram outlining the steps in producing the wood grained tiles according to the present invention.

FIG. 8 is a partial plan view of a layout of floorboard tiles in a completed installation.

DETAILED DESCRIPTION

Reference will now be made to the exemplary embodiments illustrated in the drawings, and specific language will be used herein to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended. Alterations and further modifications of the inventive features illustrated herein, and additional applications of the principles of the inventions as illustrated herein, which would occur to one skilled in the relevant art and having possession of this disclosure, are to be considered within the scope of the invention.

Referring to FIG. 1, there is shown an interlocking floorboard tile 10 having a top surface 12 with a wood grain appearance. The tile has a length L that is significantly greater than its width W, so as to resemble the typical shape of natural wood floorboards. The actual dimensions can vary. In general, to resemble a floorboard, the length L should be at least about four times the width W of the tile. In the embodiment shown in FIG. 1, the length L is about 24 inches and the width W is about 3 inches. However, tiles of different proportions may be provided. For example, shown in FIG. 8 are short

floorboard tiles 24 that are approximately half the length of the tile 10. Referring back to FIG. 1, the thickness T of the tile may be in the range of from about ¼" to ½", though tiles of other thicknesses are also possible. The tile can be made of many suitable materials, including polyolefins such as polyurethane and polyethylene, and other polymers including nylon. The exact tile dimensions and composition may depend upon the specific application to which the tile will be applied.

As shown, the top 12 of the tile 10 is a smooth solid surface, having a wood grain pattern 14 disposed thereon. Like other similar interlocking floor tiles, the tile includes loops 16 on two adjacent sides, and pins 18 on the other two adjacent sides, as shown in FIGs. 1-5. To install a floor, a tile 10 is placed on a suitable subfloor, such as concrete, with its top 12 facing up. A second similar tile is then placed parallel to and alongside the first tile, oriented such that the pins 18 of one side of the second tile are adjacent the loops 16 of a corresponding side of the first tile. The pins 18 of the second tile are then snapped into the loops 16 of the first tile, such that the sides of the two tiles are fitted snugly together. This process is continued to enable a plurality of tiles to be joined together in a single floor assembly, such as for a basketball court. The loop and pin configuration advantageously allows lateral give between the tiles, and allows for improved absorption of sudden forces that are common in games such as basketball. One embodiment of this type of loop and pin attachment system is disclosed in detail in U.S. Patent No. 4,930,286.

A plan view of a completed installation of floorboard tiles 10 is shown in FIG. 8. The locations of interlocked loops 16 and pins 18 are shown as dashes in the figure. To both provide improved strength and mimic the appearance of a natural wood floor, end joints 20 of adjacent tiles are staggered. The staggered installation configuration is made possible by a unitized spacing configuration of the loops and pins relative to the end of each plank. Viewing FIG. 1, the distance S_0 between adjacent loops or pins on the side of a given tile is constant. However, the distance S_{end} between the end loop or pin and the end of the tile is approximately equal to half of S_0. This configuration allows one side of one tile to interconnect with the interlocking structure of two adjacent tiles by straddling the end joint between those two tiles. This arrangement is clearly shown in FIG. 8, where end joints 20 between tiles fall between the locations of adjacent interlocking loops 16 and pins 18, these locations being uniformly spaced from each other, even across end joint locations.

Tiles of varying length may also be provided to further stagger the joints and provide a more random, natural wood appearance. For example, longer tiles 22 and shorter tiles 24 may be incorporated into the floor system to give a more natural look. While a tile with ten loops and ten pins on each of its long sides is shown in FIG. 1, it will be apparent that tiles of any length and with any number of loops and pins may be produced and still fit into the overall flooring system so long as they follow the unitized dimension system.

Referring to FIG. 2, there is shown a perspective view of the underside of the floor tile 10 of FIG. 1. The underside of the tile comprises an outer perimeter that is defined by a perimeter wall 26, and upright supports 28 in a lattice-type configuration that gives strength to the tile while keeping its weight low. The solid tile top 12 and lattice-type bottom structure are preferably integrally formed of the same material, such as by injection molding, so as to be structurally strong. Tiles of this general type having a grid or lattice-type support structure have been produced in a variety of configurations, as disclosed in U.S. Pat. No. 4,930,286, U.S. Pat. No. 5,787,654 and U.S. Pat. No. 5,992,106.

Referring to FIGs. 2 and 5, one embodiment of the tile 10 comprises an open hexagon bottom support structure, wherein the upright supports 28 comprise sidewalls of adjacent hexagon cells or units 30 in a repeating pattern. Alternatively, referring to FIGs. 3 and 5, the underside of the tile 10a may comprise an outer perimeter wall 26a, upright supports 28a forming sidewalls of adjacent hexagon cells or units 30a, with a plurality of elongate ribs or arches 32 disposed across the diagonal of some or all hexagon cells to form (in plan view) contiguous equilateral triangles having a common axis at the center of each hexagon. These cross ribs or arches constitute reinforcing structure that provides additional support to help distribute loads from the center of each hexagon unit to the sidewalls thereof. This helps distribute heavy loads, and reduce the risk of damage or cracking.

As noted above, prior modular interlocking flooring systems have not provided the appearance of a natural wood floor. Despite the advantages of modular polymer flooring assemblies, many people prefer the appearance of a wood floor. The present invention advantageously provides an interlocking polymer floor tile system that has an appearance resembling that of a natural wood floor.

In FIG. 6 is shown a schematic diagram of an assembly line manufacturing system 40 for producing wood grain floorboard tiles according to the present invention. The wood grain pattern is applied to the floor tiles in a post-molding process. The process begins with a floor tile 10 that has been injection molded in a manner similar to that taught in the prior art. During the molding process, pigments are preferably added to the raw plastic material to provide a desired base color. For the present invention, where it is desired to approximate the appearance of a wood floor, this color may range from a very light tan color, similar to the color of oak or hard maple, for example, to a darker brown color, similar to that of walnut or cherry flooring. Other colors may also be used.

In the process depicted in FIG. 6, the floor tile 10 is first placed on a conveyor 42, which moves in the direction of arrows 44 through a series of treatment devices that apply the wood grain appearance to the top 12 of the tile. As will be appreciated, the conveying speed of the conveyor may be adjusted depending upon the spacing and operation of the treatment devices, or the spacing and operation of the treatment devices may be determined based upon the conveying speed. The conveyor and corresponding treatment devices may be wide enough to allow the placement of several tiles side-by-side for simultaneous treatment.

Upon placement on the conveyor 42, the tile 10 initially passes through a surface treatment system 46 (step 80 in FIG. 7). The surface treatment system comprises a stationary plasma generator and/or a heater for treating the top surface 12 of the floor tile. Due to the chemical structure and simplicity of polyolefins and other polymers, their surfaces are generally resistant to permanent coating or decorating. Polyolefins, for example, are generally characterized by a nonpolar, nonporous, low-energy surface structure that does not easily bond to inks, lacquers, and other polymers without special oxidative pretreatment.

The resistance of polyolefins to coating or decorating is especially problematic when the substance to be bonded is another polymer, like polyurethane. Polyurethane has very low reactivity, is very inert, and resists reaction with organic and inorganic chemicals. It is an excellent coating for a polyolefin floor material because it is scratch and abrasion resistant, and has a long-lasting high gloss appearance.

In order to sufficiently bond a coating or decoration to a polyolefin or other polymer, the surface is treated, or a secondary adhesion-promoting layer is added to increase the adhesion. There are a number of methods for doing this, including heat or

flame treatment, the use of heat and pressure, chemical treatment, electron bombardment, and plasma or corona treatment. Of these various methods, plasma and heat treatment have a number of advantages that make them suitable to the present invention.

When a plastic surface is exposed to a high-energy electric arc plasma, the plasma interacts with the surface molecules, increasing their energy through a variety of mechanisms, depending on the specific polymer involved. In some cases, surface hydrogen is removed, leaving behind active bonding sites. Also, cross-linking or scission can occur in the surface molecules. This will change the surface energy of the material, making it easier for a coating to adhere. These are just a few of the possible chemical mechanisms by which plasma treatment increases the surface energy of a polymer material. The great benefit of using electric arc plasmas is that they are relatively low temperature, and can be used without damaging the surface of polymers and other relatively delicate materials. Through plasma treatment it is considered desirable to raise the dyne level of the tile surface to at least 72. This energy level appears to provide for complete wetting of the polymer surface, and promotes strong adhesion of coatings.

Heat or flame treatment are believed to activate the surface of the polymer primarily through the formation of oxides on its surface. These oxides are easier to bond to than the actual base polymer, thus providing more active chemical bonding sites for a coating. It will be apparent that heat or flame treatment must not heat the tile 10 to a temperature that will cause it to melt, warp, or become otherwise damaged. A temperature of between about 120° and 145° F is believed to be sufficient to activate the surface without damaging the tile. With the conveyor 42 moving at a constant speed, the top surface 12 of the floor tile 10 passing through a plasma field and/or under a heater will be approximately uniformly activated.

Following the surface treatment system 46, the activated floor tile 10 moves immediately without stopping toward the wood grain applicator system 48 (step 82 in FIG. 7). A wood grain pattern is applied to the top surface 12 of the floor tile from a transfer tape 50 that has the pattern imprinted upon it. The transfer tape is unwound from a supply roll 52, and pressed against the tile by an application roller 54 as the tile passes thereunder. The application roller is preferably heated. Through the application of heat and pressure under the application roller, the pattern on the transfer tape 50 is

transferred to the top surface of the tile, and the tape substrate 56 (now minus the pattern) is taken up on a waste roller 58.

It has been noted that the transfer tape applied to the plasma-activated surface has significantly enhanced adhesion performance over tape simply applied to the polyolefin tile. This is particularly important because of the unusually high exposure of the tile edge structure for the narrow wood grained tiles as compared to common square tiles. Indeed, the amount of exposed tile edge for a section of wood grain flooring in accordance with the present invention is as much as four times that of a square tile system. It is critical that the transfer tape not delaminate or peel back at the edges. The present invention provides an effective procedure and configuration to accomplish this objective.

It will be apparent that the floorboard tile of the present invention may be produced without the wood grain appearance – that is, bypassing the wood grain applicator system 48 and its associated step, as indicated by arrow 88 in FIG. 7. The tile 10 shown in FIG. 4 is depicted without a wood grain pattern. When injection-molded in a suitable wood-resembling polymer material, the floorboard tiles present a general wood floorboard appearance when interconnected as in FIG. 8. Without the wood grain appearance, the tiles may resemble a painted floor surface, or one treated with an opaque stain. Nevertheless, by virtue of their size and shape, the interlocking floorboard tiles of the present invention provide the appearance of a wood plank floor, even without the wood grain pattern.

Alternatively, some pattern other than wood grain may be applied to the top surface of the tile. This could include any desired pattern, such as a uniform geometric design, an irregular pattern, or pictorial images, for example. Additionally, the pattern may include multiple colors if desired. It is possible to transfer any desired pattern to the top surface of the floor tile.

Returning to FIG. 6, after receiving the wood grain pattern, the tile proceeds to a coating applicator 60 (step 84 in FIG. 7). The coating applicator is configured to roll a layer of liquid polyurethane onto the top surface of the tile covering and protecting the wood grain pattern. The coating applicator system may be a differential roll coater, as are readily commercially available. The differential roll coater includes an applicator roller 62 for directly applying the polyurethane coating to the tile 10, and a smaller "doctor" roller 64 that applies the polyurethane onto the surface of the applicator roller

and helps ensure that the polyurethane is evenly spread out on the applicator roller. One or more polyurethane supply conduits 66 supply liquid polyurethane through a nozzle to the region between the applicator roller and the doctor roller. A wiper (not shown) may also be disposed against the doctor roller to prevent liquid from dripping onto the conveyor 42. Excess polyurethane runs to the ends of the rollers and into a sump (not shown), where it is collected and recirculated to the polyurethane supply conduit.

The applicator roller 62 is provided with a resilient roller surface (e.g. 25 durometer), which allows the roller to press against and conform to any slight irregularities that may exist in the top surface 12 of the tile 10. This helps ensure good contact of the polyurethane with all areas of the tile surface. It will be apparent that the liquid polyurethane could be applied to the tile surface in other ways. For example, it could sprayed on, either automatically or manually, and could also be manually rolled on. Other alternatives are also possible. The polyurethane coating may be applied in a thickness ranging from 0.0005" to 0.002". The inventors have found that a coating thickness of 0.0015" is suitable for many applications.

The polyurethane coating is preferably a one-part all-solids (i.e non-solvent based) UV-cured aliphatic polyurethane. This type of polyurethane is well known by those skilled in the art, and is readily commercially available from paint, resin, and coating suppliers. Alternatively, other forms of polyurethane coatings may be used. For example, water based or water-borne polyurethanes, aromatic polyurethanes, and solvent-based polyurethanes could be used in alternative embodiments of the invention. Aromatic polyurethanes present the characteristic of gradually turning yellow or amber with age. Solvent-based polyurethanes require significant time and/or heating to cure, and give off noxious gasses as they do so. Other types of chemical coatings may also be used, in addition to polyurethane. For example, urethane acrylates, urethane methacrylates, epoxy acrylates, and epoxy methacrylates may also be applied using a system that is consistent with the present invention. These coatings may be desirable for their scratch, scuff, wear resistance, hardness, and ability to be cured via UV or electron beam energy.

The specific chemical make-up of the all-solids UV-cured aliphatic polyurethane described above may be adjusted for optimum adhesion and other properties, depending on the specific polymer substrate and other factors, such as environmental concerns and the anticipated use of the tile. For example, various commercially available additives

may be included in the polyurethane. Silicone may be added (from 0 to 10%) to make the polyurethane more hydrophobic, improve tape release and ease of maintenance, and to help prevent water from interfering with the bond between the polyurethane and the tile surface or another coating. Teflon powder (up to 25 microns in size) may be added (0 to 10%) to improve wear, scratch, scuff, mar, and abrasion resistance, and to modify the friction and hydrophobic characteristics of the coating.

Aluminum oxide powder (up to 50 microns in size) may be added (0 to 40%) to improve wear, scratch, scuff, mar, and abrasion resistance, and to provide increased friction. Iron oxide powder (up to 25 microns in size) may be added (0 to 5%) to provide improved wear resistance, increased friction, and to change static conductivity. Glass beads (up to 25 microns in size) may also be added (0 to 10%) to improve wear, scratch, scuff, mar, and abrasion resistance, and to provide modified friction and hydrophobic properties. Glass beads also help reflect and transmit UV light through the polyurethane coating, which will help with curing, as described below. Pigments may also be mixed into the polyurethane to provide some coloration, opacity, and other desired aesthetic characteristics. It will be apparent that there are hundreds of commercially available pigments that may be used. However, it will also be apparent that significant opacity will obscure the wood grain pattern, and can also hinder UV curing of the polyurethane coating.

Following application of the polyurethane coating, the tile 10 passes through a space 70 between the coating applicator 60 and a UV light curing system 72. This space has a length chosen in relation to the speed of the conveyor so as to provide a flattening-out time interval. This time interval allows the liquid polyurethane to flatten out before it is exposed to the UV light and cured. It will be apparent that when liquid coatings are applied with a roller, the coating may initially have ripples, dimples, and other irregularities in its surface. To allow these to dissipate, a brief time interval is needed to allow the liquid to assume a naturally flat, smooth surface under the force of gravity. Naturally, the length of the time interval required will depend on the viscosity of the polyurethane.

After the flattening-out time interval, the tile 10 enters the UV light curing system 72 (step 86 in FIG. 7). The UV light system comprises a plurality of ultra-violet lamps 74 that expose the polyurethane coating to light of a frequency that will cause the polyurethane to cure rapidly. The light is in the UV A, B, C, and V ranges at an intensity

suitable to provide the desired curing, given the speed of the conveyor 42. In one embodiment, the UV lights provide light in the 200 nm to 400 nm wavelength range, and are selectively adjustable to provide 125, 200, or 300 watts/linear inch. Suitable UV light curing systems for this application are readily commercially available.

Following curing under the UV lamps, the tile is finished and ready to install. Additional coating applicators and UV curing systems could also be provided if it were desired to apply a second or subsequent polyurethane or other coatings. However, the inventors have found that because the wood grain pattern does not alter the physical contour of the top surface of the tile, one coat is usually sufficient. The result is a smooth, flat floor tile having a top surface with the appearance of a wood floorboard with a high gloss finish.

It is to be understood that the above-referenced arrangements are only illustrative of the application for the principles of the present invention. Numerous modifications and alternative arrangements can be devised without departing from the spirit and scope of the present invention while the present invention has been shown in the drawings and fully described above with particularity and detail in connection with what is presently deemed to be the most practical and preferred embodiments(s) of the invention, it will be apparent to those of ordinary skill in the art that numerous modifications can be made without departing from the principles and concepts of the invention as set forth in the claims.